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Abstract

REACTOR PHYSICS STUDIES OF NATURAL URANIUM-LIGHT WATER MODERATED LATTICES

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The greater part of the investigation reported deals with the study of the influence of void channels surrounding the fuel on various reactor physics aspects of cylindrical uranium rods in light water.

The experimental part of the programme was carried out with the aid of an exponential assembly constructed adjacent to the thermal column of the Israel Research Reactor, which acted as a source of thermal neutrons. The hollow natural uranium fuel slugs, of 14 mm. internal and 28 mm. external diameter, were placed at the centre of aluminium tubes using aluminium spacers and leaving an air gap of 6 mm. width between the fuel and the moderator. The axial and radial flux distributions were measured experimentally by means of dysprosium foils and least squares fitted to the appropriate theoretical flux shapes to obtain the material bucklings. The lattices contain a considerable volume fraction of aluminium structural material and cladding. After applying appropriate corrections to allow for the effect of the aluminium, the buckling was found to reach a maximum of -2×10^{-4} cm^{-2} at a water to metal volume ratio of about 1.6.

The thermal flux distribution in the above lattices was calculated on the basis of monoenergetic transport theory. The boundary conditions previously applied in the spherical harmonics method to connect the moments of the angular flux at the two faces of the air gap were found to be non-unique and were replaced by a simpler set of conditions which made evaluation of higher P_L approximations possible. The calculations

of the ratio of the flux at the two faces of the gap were found to be in substantial agreement with experimental measurements. The predicted flux shape in the moderator was found to be flatter than the measured distribution. Discrepancies may be largely attributed to the neglect of thermalization effects in the calculations.

In the epithermal region, the Monte Carlo method was used as one of the principal tools for investigating the effects of void channels on the resonance capture. The Monte Carlo calculations covered energy ranges in which the main resonances of U^{238} are situated. The resonance escape probability in a lattice with air gaps was found to be somewhat larger than that in the corresponding lattice of equal volume ratio without gaps. This effect is due to the difference in the Dancoff correction in the two cases, which was determined separately and used in the semi-empirical formulae of the effective resonance integral for the lattices.

The Monte Carlo method was also used to check previous theoretical estimates of the contribution of the U^{238} p-wave resonances to the effective resonance integral. Theory shows that the contribution, which is independent of temperature, should approach the corresponding value at infinite dilution. While the Monte Carlo estimates confirm this trend, they also showed that the capture is affected to some extent by the close proximity of some p- and s-wave resonances, or p-wave resonances belonging to different values of the total angular momentum J of the compound nucleus.